

**Problem 2.8** Find  $\alpha$ ,  $\beta$ ,  $u_p$ , and  $Z_0$  for the two-wire line of Problem 2.2. Compare results with those based on CD Module 2.1. Include a printout of the screen display.

**Solution:** From Problem 2.2:

$$\begin{aligned}R' &= 3.71 \, \Omega/\text{m}, \\L' &= 1.36 \times 10^{-6} \, \text{H/m}, \\G' &= 1.85 \times 10^{-6} \, \text{S/m}, \\C' &= 2.13 \times 10^{-11} \, \text{F/m}.\end{aligned}$$

At 2 GHz:

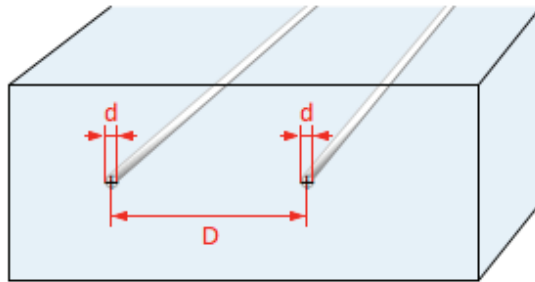
$$\begin{aligned}\gamma &= \sqrt{(R' + j\omega L')(G' + j\omega C')} \\&= 0.0076 + j67.54.\end{aligned}$$

Hence

$$\begin{aligned}\alpha &= 0.0076 \, \text{Np/m}, \\\beta &= 67.54 \, \text{rad/m}, \\u_p &= \frac{\omega}{\beta} = \frac{2\pi \times 2 \times 10^9}{67.54} = 1.86 \times 10^8 \, \text{m/s}, \\Z_0 &= \sqrt{\frac{R' + j\omega L'}{G' + j\omega C'}} = 253 \, \Omega.\end{aligned}$$

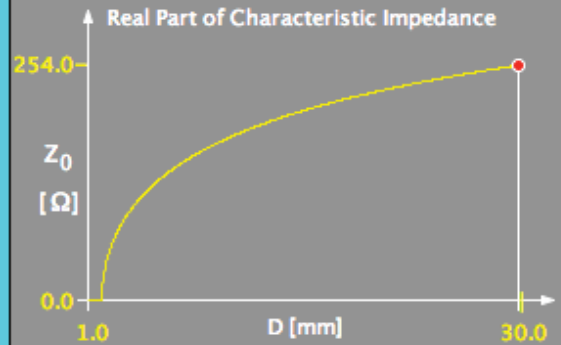
## Module 2.1 Two-Wire Line

Select: Impedance vs. Distance D



Substrate  
 $\epsilon_r = 2.6$   
 $\sigma = 2.0E-6$  [S/m]

Wires  
 $\sigma_c = 5.8E7$  [S/m]



### Input

Wire Diameter  $d = 2.0$  [mm]

Range

Centers distance  $D = 30.0$  [mm]

Range

Frequency  $f = 2.0E9$  [Hz]

Range

$\epsilon_r$   $\sigma$  [S/m]  $\sigma_c$  [S/m]  
 2.6 2E-6 5.8E7

Update

### Output

$f = 2.0$  [GHz]

#### Structure Data

$d = 2.0$  [mm]  $D / d = 15.0$   
 $D = 30.0$  [mm]

$Z_0 = 253.037142 - j 0.026617$  [Ω]

$C' = 21.241303$  [pF/m]

$L' = 1.360034$  [μH/m]

$R' = 3.713907$  [Ω/m]

$G' = 2.0E-6$  [S/m]

$\lambda_0 = 0.15$  [m] in vacuum

$\lambda = 9.3026$  [cm] in guide

$\alpha = 0.007572$  [Np/m]

$\beta = 67.542213$  [rad/m]